

We claim:

1. A method of estimating the results of a database query, the method comprising:

5 collecting workload information related to the database;
 tracing query patterns of queries in the workload to identify the usage of
tuples in the database during execution of the queries;
 determining sample weights based on tuple usage; and
 performing a weighted sampling of the database based upon the sample
10 weights.

2. The method of claim 1 wherein the weighting sampling is based on a probability of usage of tuples required in executing the workload.

15 3. The method of claim 2 and further comprising computing an aggregate over values in each sampled tuple.

4. The method of claim 3 wherein the aggregate is computed by multiplying each value by the inverse of the probability with which corresponding tuples
20 were sampled.

5. The method of claim 1 wherein the weights are a function of the frequency of access of a tuple and the number of queries in the workload that access the tuple.
25

6. The method of claim 1 wherein the tuple usage is stored on a page level.

7. A machine readable medium having instructions for causing a machine to perform a method of estimating the results of a database query, the method
30 comprising:

 collecting workload information related to the database;

Sub
B

FOIA b 7 - D

B

14. A system that estimates the results of a database query, the system comprising:
 - means for performing a weighted sampling of tuples in the database
 - 5 based on a probability of usage of tuples required in executing a given workload;
 - means for storing the probability for each tuple sampled;
 - means for computing an aggregate over values in each sampled tuple
 - while multiplying by the inverse of the probability with which each tuple was
 - sampled.
- 10 15. A machine readable medium having instructions for causing a machine to perform a method of estimating the results of a database query, the method comprising:
 - performing a weighted sampling of tuples in the database based on a
 - 15 probability of usage of tuples required in executing a given workload;
 - storing the probability for each tuple sampled;
 - computing an aggregate over values in each sampled tuple while
 - multiplying by the inverse of the probability with which each tuple was sampled.
- 20 16. A method of sampling tuples in a database to estimate the answer of an aggregation query, the method comprising:
 - determining which tuples are accessed more often during execution of a
 - workload;
 - sampling the tuples; and
 - 25 calculating an aggregate of values in the sampled tuples as a function of
 - which tuples are accessed more often.
17. A method of generating an outlier index for a database and a given workload wherein the queries in the workload may have selection or group by
- 30 conditions, the method comprising:
 - identifying sub-relations of tuples in the database induced by selection
 - and group by conditions in queries in the workload;
 - generating a variance for values in each sub-relation;

generating weights for each sub-relation based on workload information;
generating a weighted variance for values in an aggregation column in
each sub-relation;

allocating memory to sub-relations in proportion to their weighted
5 variances; and

generating outliers from such sub-relations based on allocated memory.

23. The method of claim 22 and further comprising a module that takes a
union of outliers generated from such sub-relations.

10 24. The system of claim 22 wherein sub-relations are selected having a
weighted variance higher than a desired threshold.

25. The method of claim 22 wherein the weights are a function of a number
15 of queries in the workload that reference the sub-relation.

26. A method of generating an outlier index for a database and a given
workload wherein the queries in the workload may have selection or group by
conditions, the method comprising:

20 identifying sub-relations of tuples having values to be aggregated;
generating weights for sub-relations based on workload information;
generating a weighted variance for values in sub-relations;
selecting sub-relations having higher weighted variances; and
generating outliers from such sub-relations having higher weighted

25 variances.

27. The method of claim 26 and further comprising taking a union of outliers
generated from such sub-relations.

30 28. The method of claim 26 wherein sub-relations are selected having a
weighted variance higher than a desired threshold.

00759304-01204
FOUO

B1

29. The method of claim 26 wherein the weights are a function of a number of queries in the workload that reference the sub-relation.

30. A machine readable medium having instructions for causing a machine to perform a method of generating an outlier index for a database and a given workload wherein the queries in the workload may have selection or group by conditions, the method comprising:

- identifying sub-relations of tuples having values to be aggregated;
- generating weights for sub-relations based on workload information;
- 10 generating a weighted variance for values in the sub-relations;
- selecting sub-relations having higher weighted variances; and
- generating outliers from such sub-relations having higher weighted variances.

31. A system that generates an outlier index for a database and a given workload wherein the queries in the workload may have selection or group by conditions, the system comprising:

- means for identifying sub-relations of tuples having values to be aggregated;
- 20 means for generating weights for each sub-relation based on workload information;
- means for generating a weighted variance for values in each sub-relation;
- means for selecting sub-relations having higher weighted variances; and
- means for generating outliers from such sub-relations having higher
- 25 weighted variances.

32. A method of estimating the results of a database query over a relation, the method comprising:

- defining weights of sub-relations using workload information;
- 30 calculating a weighted variance for each sub-relation;
- allocating memory to sub-relations in proportion to respective weighted variances;

B1

building an outlier index for each sub-relation in accordance with
allocated memory; and
taking the union of outlier indexes.

5 33. The method of claim 32 and further comprising retaining sub-relations
having a weighted variance over a desired threshold prior to allocating memory
to sub-relations.

34. The method of claim 32 wherein each weighted variance is a function of
10 the weight of a sub-relation and the variance of the sub-relation.

35. A method of estimating the results of a database and a given workload
wherein the queries in the workload may have selection conditions, the method
comprising:

15 collecting workload information related to the database;
tracing query patterns of queries in the workload to identify the usage of
tuples in the database during execution of the queries;
determining sample weights based on tuple usage;
performing a weighted sampling of the database based upon the sample
20 weights; and
generating a weighted outlier index.

36. The method of claim 35 and further comprising calculating an aggregate
based on the samples and the index.

25 37. A method of estimating an aggregate result of a database and a given
workload wherein the queries in the workload may have selection or group by
conditions, the method comprising:

30 collecting workload information related to the database;
tracing query patterns of queries in the workload to identify the usage of
tuples in the database during execution of the queries;
generating sample weights based on tuple usage;
performing a weighted sampling based upon tuple usage;

B1

- generating an aggregate based on the weighted sampling;
- identifying sub-relations of tuples in the database induced by selection and group by conditions in queries in the workload;
- generating weights for each sub-relation based on workload information;
- 5 generating a weighted variance for values in an aggregation column in each sub-relation;
- allocating memory to sub-relations in proportion to their weighted variances;
- generating outlier indexes from such sub-relations based on allocated
- 10 memory;
- performing a union on the outlier indexes to form an outlier index for the relation;
- computing an aggregate on the outlier index for the relation; and
- combining the aggregate based on the weighted sampling with the aggregate on
- 15 the outlier index.

38. A method of estimating the results of a database and a given workload wherein the queries in the workload may have selection conditions, the method comprising:

- 20 building an outlier index on outlier values;
- building a sample of non-outlier values;
- aggregating the outlier values and non-outlier values and scaling values as required.

25 39. The method of claim 38 wherein the outlier index is built using workload information.

40. The method of claim 38 wherein the non-outlier sample is based on uniform sampling.

30 41. The method of claim 38 wherein the non-outlier sample is based on weighted workload information.